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PULSED SOUNDS OF THE PORPOISE *LAGENORHYNCHUS AUSTRALIS*

William E. Schevill and William A. Watkins[1]

Abstract. Pulsed sounds of the porpoise *Lagenorhynchus australis* of southern Chile were recorded and analyzed. Most were low-frequency clicks; some had a 2-kHz bandwidth centered near 1 kHz, and others had a 10- or 12-kHz bandwidth with the principal frequency in the lower 5 kHz. These porpoises also produced a rapidly pulsed tonal sound. All these sounds were very low-level and rarely audible at a distance as great as 20 m. We heard none of the whistlelike squeals characteristic of many delphinids.

From 12 November to 11 December 1968 the research ship HERO of the National Science Foundation (Antarctic Research Program) cruised between Valparaiso and Cape Horn, searching for cetaceans and pinnipeds, mostly in the sheltered inland waterways of southern Chile. We were concerned with listening for and recording the underwater sounds of these animals.

The species most frequently seen and collected was *Lagenorhynchus australis* (Peale, 1848), which has been reported from the west coast of Chile south of about S Lat. 40° around Cape Horn to the Falkland Islands. We heard them much less often than we saw them.

Methods. The recordings that are analyzed here were made on 23 November in Canal Messier (at 48° 10′ S) and 1, 3, 5, and 6 December west and south of Navarino Island behind Cape Horn. An Atlantic Research LC-34 hydrophone was used to pick up the sounds. An impedance-matching pre-amplifier (WHOI) was inserted in the cable 30 cm from the hydrophone. Two cable lengths

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were used, 125 m from R/V HERO and 30 m from HERO's whaleboat. The hydrophone depth varied with local conditions and experiments, from 2 m to nearly 125 m; it was usually suspended 6-8 m from a surface float (a rubber balloon) and allowed to drift as far from ship or boat as cable-length permitted.

Tape recordings were made with either a modified Uher 4400 recorder or a WHOI-built springwound recorder, using a hydrophone amplifier (Watkins, 1963). When the Uher was in use, the system-response was limited to a bandwidth, within 4 db, of 40 to 20,000 Hz; with the WHOI machine, system-response was 20 to 32,000 Hz (within ½ db from 30 to 30,000 Hz). Playback for analysis was on Crown 800 tape recorders. Spectrographic analyses were made on a Kay Electric model 7029A analyzer and amplitude analyses on a Tektronix 535A oscilloscope.

The porpoises were approached as closely and as unobtrusively as possible, but even so, often the only sounds heard from the animals were within the first 5 seconds of the listening attempts. Unfortunately, because of the disturbance of the water by arrival of the boat and the motion of the hydrophone, a longer time than this usually was required before local ambient noise could settle down enough for faint sounds to be recorded. Usually nothing was heard from the porpoises, partly because they were generally taciturn and seemed to produce sounds only occasionally, and partly because their sounds were too faint to be audible except on close approach, within a few meters of the animals. They appeared to be silent when disturbed.

Sounds. The sounds heard from *Lagenorhynchus australis* were all pulsed. Mostly they were clicks produced in short series or slow bursts, but sometimes a rapidly pulsed sound (a buzz) that had a tonal quality was heard. The buzz was the only sound heard from *L. australis* at any distance, and it was produced only occasionally; consequently most attempts to listen to these porpoises were entirely unsuccessful. No squeals (whistles) were heard; this was unexpected since we have heard squeals from other *Lagenorhynchus* (*L. albirostris, acutus, obliquidens,* and the *obscurus* of New Zealand).

These sounds of *L. australis* were low level and generally inaudible beyond about 10-20 m. We estimate that the loudest clicks were no more than −20 db re 1 dyne/cm^2 at 1 m, from known hydrophone sensitivities and tape saturation levels, and

assumed supply voltages and amplifier gains. On only a few occasions were we convinced that we knew which individual produced the sounds that we heard, and therefore our estimates of signal strength and of distance from the hydrophone are but guesses.

The click-sounds were of two types: a broadband click, and a relatively restricted-bandwidth click (narrowband) at predominantly low frequencies. These two clicks never seemed to be mixed. Both types were heard, we thought, from any one individual, with no obvious separation between the different kinds of clicks, and no gradual transition. Though both types of clicks were sometimes heard at slow rates (1 or 2 per sec.), the broadband click was usually produced at a more rapid repetition-rate (20 to 80 per sec.) than the narrowband click (5 to 25 per sec.). The broadband click was shorter and had less energy at low frequencies than the narrowband click. See the table for a comparison of these two clicks.

The broadband click (Figs. 1A and 2) was characterized by a sharp onset, a short duration, as well as a more or less continuous spectrum to 10 or 12 kHz, occasionally to 16 kHz. Analyses of clicks showed a general drop in intensity of 1 to 2 db per 1000 Hz above 5 or 6 kHz. This drop was greater than is consistent with normal frequency-selective absorption for these distances and frequencies, so we assume that this attenuation is characteristic of the click of *L. australis*. The duration of the broadband click was consistently a little less than 1 msec. Because of the general low level of the sounds as well as their usual reduction in intensity at higher frequencies, the clicks were easily masked by background ambient.

The narrowband click (Figs. 1B and 2) was restricted in frequency to the lower 2000 Hz and appeared to have its greatest intensity at or below 1000 Hz. Harmonics did exist, though at greatly reduced levels. Analysis at high gain (but still undistorted) showed some of the narrowband clicks with harmonic frequencies to 5 or 6 kHz. The narrowband click, with a duration of 1.5 to 3 msec., usually occurred at slower repetition-rates (5 to 25 per sec.), and consistently had higher intensity at low frequencies than the broadband click. Perhaps because of its lower-frequency emphasis and therefore better transmission characteristics, the narrowband click was the one most commonly heard.

The third type of sound, the buzz (Fig. 3) was heard on a few

occasions. This buzz had emphasis at discrete higher frequencies, such that both the fundamental and high frequency overtones were predominant in the aural impression of the sound. The buzzes varied in duration from 0.6 to 1.1 sec. They were composed of a pulsed fundamental near 300 Hz (Fig. 4) and strong overtones at 4 to 5 kHz. Two or three sidebands of the pulse repetition-rate (modulation, Fig. 1C) may be noted grouped around the 4- to 5-kHz overtone in spectral analysis (Fig. 3) of these buzzes (see Watkins, 1967). The fundamental frequency of the buzz was more intense than the overtones, yet at greater distances only the 4- to 5-kHz tone (with its associated sideband structure) was audible. This was probably because of higher background ambient at the lower frequencies. The buzz appeared to be produced at a higher level than the clicks.

Discussion. Because of both the pulsed quality of the buzz and its restricted frequency, we suppose that this sound was formed by rapidly repeated narrowband clicks. Singly, the narrowband clicks had few higher frequency components, but in a rapid series the overtones were prominent. This is somewhat similar to sounds produced by *Phocoena phocoena,* composed of a rapid repetition of narrowband clicks to form a continuous sound with selected higher frequency emphases (Schevill, Watkins, and Ray, 1969). We did not find the variation in the overtones of the buzz of *L. australis* that we noted for *Phocoena,* but this may have been due to the limited number of the former's buzz sounds that were recorded well enough for such detailed analysis.

Perhaps the buzz was used in communication and it may have been associated with stress. This could explain its relatively infrequent occurrence. The only time that the buzz was heard when we thought we knew which porpoises were producing it (in Paso Micalvi outside of Seno Grandi, Navarino Island, 6 December), a group of three animals 15 to 20 m distant suddenly seemed to be in a scuffle. darting at and away from each other. This sudden unusual activity coincided with the production of four buzzes, two of them concurrently (Figs. 3 and 4), and so we assume that these sounds were produced by these porpoises.

We have no evidence that *Lagenorhynchus australis* echolocates. If the click sounds were used for echolocation as in some other species (*Tursiops truncatus, Steno bredanensis, Orcinus orca, Phocoena phocoena*), it must have been at relatively close ranges

because of the low level of the clicks. We did not hear any "accelerando" in click series such as is typical of echolocation runs during feeding by these other animals; however, we had no suggestion that the *L. australis* were feeding when the clicks were heard. In fact, the clicks were not consistently associated with apparently investigatory behavior by the animals. Porpoises sometimes passed within a meter of the hydrophone and even appeared to return and examine it without our detecting any sounds. On the other hand, clicks were never heard unless a porpoise was close by.

The two click-types perhaps are equivalent to the two basic click-categories noted for *Tursiops* by Norris, Evans, and Turner (1967). They name these clicks by their function, "discrimination clicks" and "orientation clicks." The discrimination click of *Tursiops* has a reduced bandwidth and emphasis of lower frequencies, while the orientation click has a wide bandwidth. In these respects they match the sounds heard from *L. australis*, though no behavioral correlation was possible.

Although two types of clicks were heard, one with a relatively restricted low frequency and other with broadband characteristics, it suggests the possibility that only one click type exists in reality and the variations noted result from changing orientation by an animal possessing a directional sound system. Other cetaceans have been shown to have such a directional sound field (*Tursiops*, Norris, Prescott, Asa-Dorian, and Perkins, 1961; *Orcinus*, Schevill and Watkins, 1966; *Steno*, Norris and Evans, 1967; and, *Platanista*, Evans in Herald et al., 1969). Our data is insufficient to rule out this possibility completely, but the evidence that we have seems to argue instead for two distinct click types:

1. The click durations of the two types are different. High frequency emphasis in a low frequency click would not shorten the length of the pulse but would simply extend the bandwidth.
2. The two click-types suddenly interchange with no pause between. We have no examples of a gradual shift from one type to the other and we have very few individual clicks whose characteristics are intermediate in form. Some of the subtle variations observed in the higher frequency components of successive clicks of both types, however, may result from such directionality, though we did not have opportunity to observe any correlation of orientation with bandwith.

Because of the difficulties we encountered in hearing the porpoises, we were impressed with the low level of their sounds. We also were acutely aware that it was not high background that obscured their sounds, since the ambient noise levels in this region were actually very low. Without carefully and recently calibrated equipment, such low sound-levels are difficult (and probably meaningless) to assess; however, our limitation much of the time appeared to be the self-noise of the equipment rather than the local ambient background. Perhaps the land barriers shielded the inland channels from the usual open sea sounds and at the same time provided enough shelter so that very little local wind and wave noise was generated. In addition, we recognized very little contribution of sound from other biological sources, and certainly these porpoises had but small influence on the local ambient sound.

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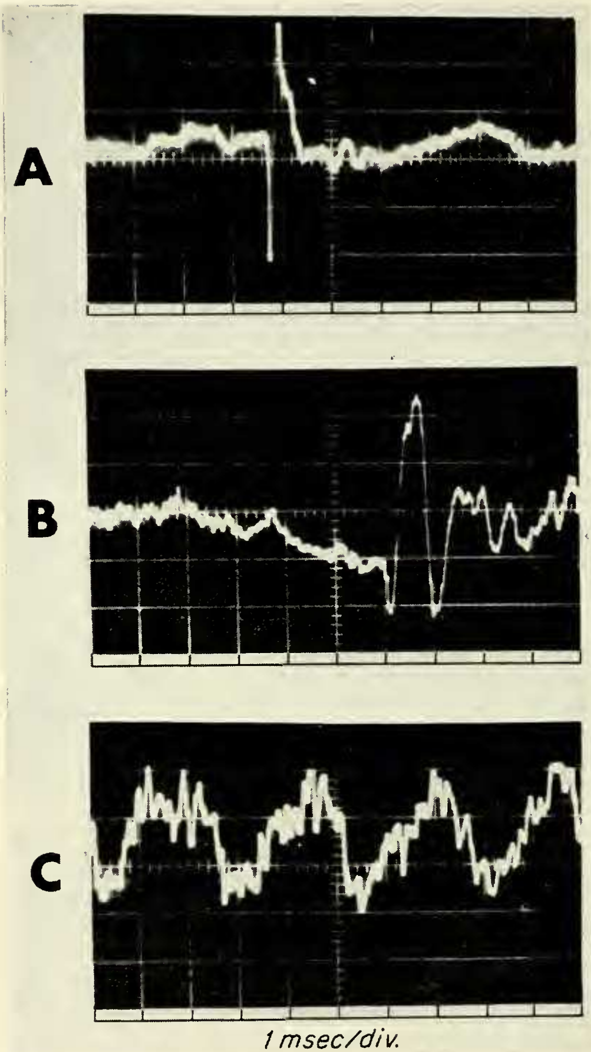

Figure 1. Oscillographic pictures of (A) the broadband click, (B) the narrowband click, and (C) the pulse modulation of the buzz. Ambient noise is superimposed on these sound traces.

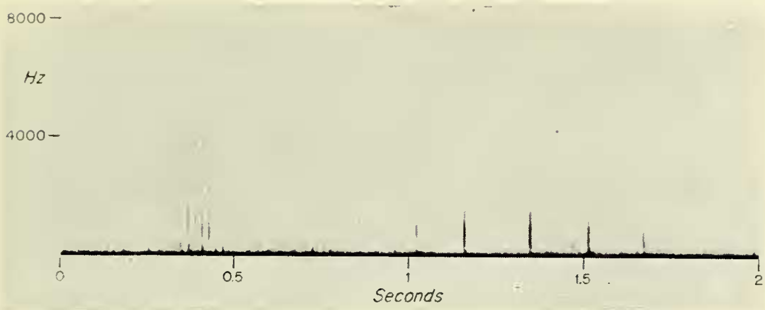

Figure 2. Spectrographic analysis shows a burst of broadband clicks followed by narrowband clicks. Although the latter become much greater in amplitude as the animal comes closer, the frequency spectrum remains relatively restricted. The bandwidth of the analyzing filter is 300 Hz. This figure is the result of a repetitive analysis, with a small horizontal displacement of the paper between analyses to widen artificially the traces of these short-duration sounds for better photographic reproduction.

	Narrowband click	Broadband click
Bandwidth	2 kHz	10 or 12 kHz
Principal frequency	1 kHz or less	from less than 1 to 5 kHz
Duration	1.5 to 3 msec	0.8 to 1 msec
Repetition rate	5 to 25/sec	20 to 80/sec
Intensity (re 1 dyne/cm^2)	−20 db at principal frequency	−20db spread over bandwidth

Table of characteristics of the two types of click heard from *Lagenorhynchus australis*.

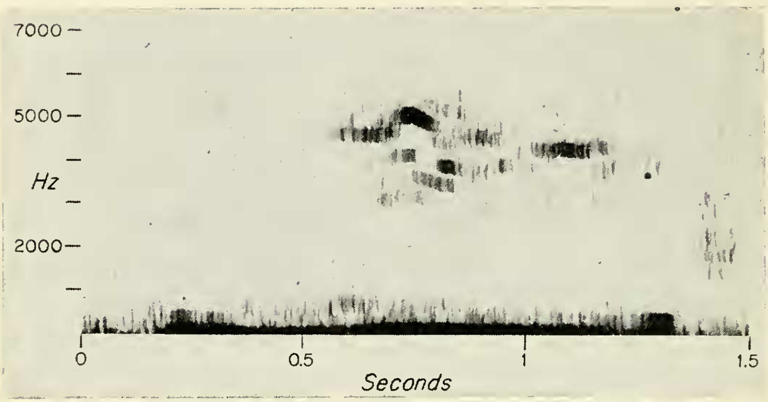

Figure 3. Two simultaneous buzzes have emphasis in the 4- to 5-kHz region as well as a strong fundamental at about 300 Hz. The analyzing filter bandwidth is 300 Hz. Compare Fig. 4.

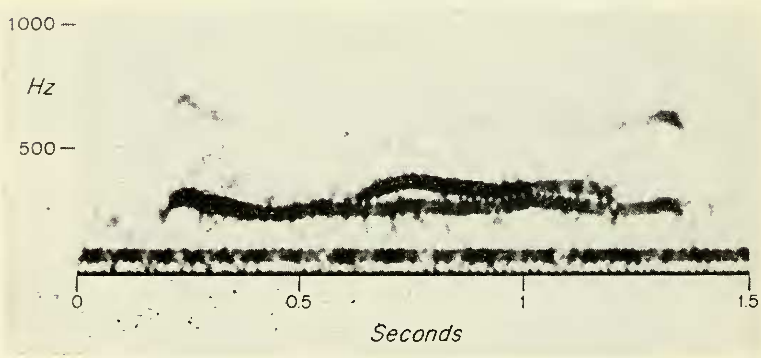

Figure 4. The fundamental frequencies of the same two buzzes shown in Fig. 3 show variation in the region of 300 Hz. The continuous low frequency band is ship's propulsion noise from the HERO about 5 or 6 miles away. The analyzing filter bandwidth is 45 Hz.